

BACKGROUND INFORMATION transparencies were then photographically composed and enlarged, resulting in color transparencies and Landsat 1 (formerly ERTS-1) was launched by the color prints at 1:250,000 scale U.S. National Aeronautics and Space Administration Parts from each MSS image were selected for (NASA) on July 23, 1972, and Landsat 2 on January 22 processing and were mosaicked together, giving complete 1975. The satellites maintain near-polar, suncoverage of the quadrangle. Corrections for atmospheric synchronous, circular orbits approximately 920 km effects, sun elevation, noise, and geometric distortions above the Earth's surface and circle the Earth every were applied to the mosaicked image. 103 minutes, or roughly 14 times per day. In order For maximum interpretation of surficial spectral to maintain the sun-synchronous orbit, each orbital reflection data, three types of computer-enhanced products were generated for study: 1) false-color pass is from north to south, allowing each satellite to view the Earth at the same local time, approximately with "sinusoidal" stretch, 2) simulated natural color, 9:30 a.m. at the Equator. From such a vantage point, and 3) color ratio. each Landsat can cover the entire Earth, except for Three sinusoidally stretched false-color images the poles, in 18 days. were produced by various combinations of three of the The Landsat spacecrafts carry two imaging systems, four bands. After the standard corrections mentioned the Multispectral Scanner (MSS) and the Return Beam above, histograms of the different bands are analyzed Vidicon (RBV), which record reflected visible and to determine the ranges of DN values containing near-infrared radiation. Owing to an electronic significant data. The maxima and minima of each of malfunction in Landsat 1, the RBV system was turned these ranges of DN values are then used as limits, off after about one month of operation. The MSS and the intervening data are sinusoidally stretched system, however, continued to function properly, (adjusted by computer) to occupy the entire dynamic recording images with high spatial resolution (about range of DN values -- the first set of data from 0 to 80 m) in four discrete spatially registered spectral 127 DN, the second set from 127 to 0 DN, the next set bands: band 4, 0.5-0.6 μ m; band 5, 0.6-0.7 μ m; band 6 from 0 to 127 DN, and so on. This stretch enhances $0.7-0.8 \mu m$; band 7, $0.8-1.1 \mu m$. Measurements are not only large spectral differences within the image; transmitted to receiving stations on the ground, and but also very subtle differences not usually enhanced the data are subsequently digitized, calibrated, and by other methods. The resulting image shows gradual color changes for small differences of gray levels. converted to pictorial images. Each image covers an area of approximately 185 X 185 km (34,225 km²). A black and white image for each individually stretched Overlap is 10 percent with preceding and following band is then produced as a film positive (transparency) images and ranges from about 14 percent sidelap at the at approximately 1:1,600,000 scale (two different Equator to 85 percent sidelap at 80° north and south sinusoidal stretches were applied to band 5). These transparencies are then photographically registered Analysis of Landsat images can be made by various and optically filtered to generate a color transparency methods including 1) the visual interpretation of at the same scale. The color combinations used for black and white transparencies or prints of individual bands, 2) the visual interpretation of false-color composite prints, transparencies, or diazo composites made by optically combining images of several bands, and 3) the use of a multispectral viewer that optically generates false-color images. All of these techniques, however, have an inherent problem -- the inability of photographic materials to reproduce the entire spectral

reflectance ranges of the different bands. To circum-

system are digitized before being converted to pictorial

system calibration, the reflectance ranges are recorded

on tape as digital numbers (DN) ranging from DN 0 to

band 7. CCT's are produced from these magnetic tapes

and are available in three formats from the EROS Data

per inch, and odd parity, on 4 tapes; 2) 9-track, 800

bits per inch, and odd parity, on 2 tapes; and 3) 9-

track, 1600 bits per inch, and odd parity, on 1 tape.

quadrangle, Alaska, two techniques were used: the

visual study of a Landsat mosaic of Alaska, and the

study of various types of computer-enhanced Landsat

Conservation Service, using band 7 images generated

without computer enhancement. Study of this mosaic

of the synoptic perspective and low sun angle, the

and circular patterns. Tonal variations signifying

by snow on the Alaska mosaic.

circular features and relating them to regional linear

differences in ground color within the quadrangle are

not detectable because the area is completely covered

On the basis of minimal snow and cloud cover,

two Landsat 1 images were selected for computer

enhancement: 1350-20223, taken July 8, 1973; and

1709-20090, taken July 2, 1974. In addition to

imagery is generally most useful for identifying

subtle surficial reflectance variations due to

Survey, Flagstaff, Ariz. Computer-enhancement

techniques were applied using a Digital Equipment

white film transparencies. The black and white

Corporation, Computer PDP 11/45 1, yielding computer-

enhanced CCT's, which were then used in an Optronics

dentifying other linear and circular features not

detected on the Landsat photomosaic, computer-enhance

differences in vegetation, rock types, soil, and other

by the image processing facility of the U.S. Geological

Company, Photowrite 1500 System to generate black and

The use of trade names is for descriptive purposes only and does

not constitute an endorsement of these products by the U.S.

CCT's for these two Landsat scenes were processed

mosaic was most useful for identifying linear and

results transcribed to fit a standard 1:250,000-scale

UTM projection map of the McCarthy quadrangle. Because

was conducted at a scale of 1:1,000,000, and the

1973 by the U.S. Department of Agriculture Soil

The Landsat mosaic of Alaska was constructed in

Center, Sioux Falls, South Dakota: 1) 7-track, 800 bits

In this study of Landsat imagery for the McCarthy

7 for bands 4, 5, and 6, and from DN 0 to 63 for

vent this problem, computer enhancement techniques

Because reflectance data recorded by the MSS

may be applied to computer compatible tapes (CCT's).

images, the entire spectral reflectance ranges are

available on magnetic tape. After application of a

OBSERVED IRON-OXIDE COLORED AREA

NUMBERED AREAS DESCRIBED

CIRCULAR FEATURES. DOTTED

ARE DESCRIBED IN TEXT.

WHERE UNCERTAIN, LETTERED

FEATURES ARE DESCRIBED IN

LINEAR FEATURES. DOTTED WHERE

UNCERTAIN, LETTERED FEATURES

1) band 5 (#1), green; band 5 (#2), red band 7, blue (P.A.O. no. E-455-57CT) 2) band 5 (#2), red; band 6, green; band 7, 3) band 5 (#1), green; band 6, blue; band 7 red (P.A.O. no. E-456-57CT). Finally, the false-color transparencies are photographically enlarged and printed at 1:250,000 scale. Although bands 4 and 5 measure reflected light in the yellow-green and red-orange regions of the visible spectrum, respectively, bands 6 and 7 measure in the invisible, near-infrared region. The blue part of the visible spectrum is not recorded. Photographically generated color Landsat images, therefore, cannot show actual surficial color conditions. Simulated natural-color images can be generated using generation of a synthetic blue component from the data f the four MSS bands. A version of Landsat data is thus produced in which the colors approximate those which the human eye should see from orbital altitudes f atmospheric absorption and scattering were eliminated (Eliason and others, 1974). As in the false-color images, the four quarters of the image are mosaicked together, and black and white transparencies of band 4, band 5, and of the extrapolated blue band are produced. In generating the final color products, the three black and white transparencies are optically ltered using green for band 4, red for band 5, and blue for the synthetic blue band. The final product simulates true color and accentuates subtle color lifferences (P.A.O. no. E-457-57CT). The third type of computer-enhanced product is

a color ratioed image. Ratioing involves dividing the DN values of pixels in one spectral band by the DN values of corresponding pixels in another spectral and. The resulting image tends to eliminate variations in color of a given material due to topographic effects or shadows. On the other hand, differences in albedo are reduced, and different materials, easily discriminated on a standard photographic image, may become visually identical or similar. Histograms of ratioed images tend to have a narrow range of DN values. As a result, this narrow range of DN values is "computerstretched" to fill the entire dynamic range of values, giving greater variations in color. The type of stretch is dependent upon the brightness of the area of interest. Effects of noise and atmosphere are greatly enhanced by ratioing, requiring extra care in the early computer processing stages. For this study the ratios are as follows: band 5/4, band 7/4, band 6/7 The quotients were converted into black and white transparencies that were combined into the final color composite product, using red for 7/4, green for 6/7. and blue for 5/4 (P.A.O. no. E-458-57CT).

Computer-enhanced color products generated by the U.S. Geological Survey, Flagstaff, Ariz., are available at nominal cost from: EROS Data Center, Sioux Falls, South Dakota, 57198. Orders should include P.A.O. (Public Affairs Office) numbers given elsewhere in this text.

For this study, the most useful application of the 1:1,000,000-scale Alaskan Landsat mosaic, prepared by the Soil Conservation Service, is the identification 30-35 km (or multiples thereof) apart. This set is of linear and circular features. These features are traced onto a scale-stable plastic overlay, then hotographically enlarged to a scale of 1:250,000. The final plotted locations of the various linear and circular features are accurate to within only about 1 km because of optical distortions and differences in projections (the mosaic is Albers Equal Area, and the map, Universal Transverse Mercator). This is not a significant problem, however, because most linear and circular features appear to be zones, many of

which are wider than 1 km. Linear Features Two approaches were used in mapping linear features from Landsat images: 1) identification of linear features independent of any background geologic data, and 2) identification of potential extensions of mapped faults. These two approaches are based upon the assumption that fundamentally different phenomena are responsible for two types of linear features == types A and B. Type A linear features represent a worldwide regmatic shear pattern or planetary fracture system (Sonder, 1947; Shul'ts, 1971), whereas type B inear features are related to faults, folds and fractures that are probably the result of local and regional tectonics. Hobbs (1911) was one of the first workers to discuss rectangular sets of fracture patterns and to relate them on a worldwide basis. He noticed that inear patterns in Europe, North America, Africa, and Asia form a primary fracture pattern of two intersecting rectangular sets of subequally spaced and vertical fractures. He concluded that this pattern is the result of generally uniform conditions of stress and strain throughout the Earth's crust.

Vening Meinesz (1947) cited extensive evidence for a system of shear planes throughout the Earth's crust and concluded that this system is probably caused by a change of the axis of flattening due to shifting of the Earth's rotation axis with respect to the crust. In response to Vening Meinesz' paper, Sonder (1947) proposed the term "regmageny" to describe problems related to worldwide fracturing of the Earth's crust, and to distinguish this type of fracturing from that caused by local tectonics. Sonder agreed with Vening Meinesz that polar shifts have played a part in the formation of the regmatic shear pattern but believed that large fluctuations of the elastic compression stored in the Earth's crust, in the presence of global elastic anisotropies of considerable magnitude and unequal crustal tangential stresses (orogenic orces), may also be significant Shul'ts (1971) distinguished planetary fractures (regmatic fractures) from structures caused by tectonic deformations. He believed that these rectilinear planetary fractures are genetically related to internal stresses in rocks and that the orientation of the fractures, which is related to planetary rotational stresses, divides the Earth's crust into blocks of different size and importance. According to Shul'ts, fractures, along with faults and folds, can also be related to local and regional tectonic stresses, which are generally subordinate to the network of planetary cacturing and controlled by factors of their own. For the most part, Hobbs, Vening Meinesz, Sonder, and Shul'ts have found two orthogonal sets of planetary ractures or regmatic shear directions, one set northwest and northeast, and the other set north and east. In the McCarthy quadrangle, however, we found three orthogonal sets of type A linear features, similar to those observed in the Nabesna quadrangle (Albert, 1975) (figs. 2 and 3). The most prominent set trends approximately N. 47° W. and N. 48° E.,

while the other sets trend approximately north and N. 88° E., and N. 72° W. and N. 15° E. Only the third set appears to have a different orientation from the common regmatic shear or planetary fracture Most of the observed type A linear features corresponding to these three orthogonal sets range from several tens to several hundreds of kilometres long. The more north-trending type A linear features are significantly less continuous and more poorly developed than those with other orientations. Northwest-, northeast-, and east-trending type A linear features exhibit spatial periodicity. Parallel linear features with any of these trends tend to be spaced approximately 30-35 km apart. Applying Vogt's (1974) method for estimating crustal thickness from the spacing of volcanoes and major fractures, the spacing of type A linear features in the Wrangell Mountains, within the McCarthy quadrangle, indicates a crustal thickness of approximately 30-35 km. This thickness is somewhat less than gravimetrically derived estimates of approximately 45 km by Barnes

Spacing of the N. 72° W. and N. 15° E. orthogonal evidence that the N. 72° W. linear features are spaced oriented approximately 15° in a clockwise direction from the north- and east-trending set and approximately 30° in a counter-clockwise direction from the northeastand northwest-trending set. Since the orientation of the N. 72° W. and N. 15° E. set does not appear to correspond to the common regmatic shear or planetary fracture patterns, we believe that regional tectonics may have played a significant role in either its formation or modification. Linear feature A, with an approximate N. 72° W. fault system on the west side of the Alaska Range, near Farewell, to the southwest corner of Yukon Cerritory, Canada, is the longest linear feature observed (fig. 1). Corresponding grossly to the Border Ranges fault for several tens of kilometers, flysch-type sedimentary deposits of the Chugach Mountains to the south, and the upper Paleozoic and younger volcanic and associated sedimentary and

CONTOUR INTERVAL 200 FEET

DATUM IS MEAN SEA LEVEL

trend and extending at least 750 km from the Denali it marks the approximate boundary between the Mesozoic intrusive rocks of the Wrangell Mountains to the north (MacKevett, 1976a). Linear feature B, with an approximate N. 45° W. trend in the McCarthy quadrangle, extends at least 620 km from the Tanana River, west of Fairbanks, to the southwest corner of Yukon Territory, Canada, intersecting the Denali fault system near its northernmost part and following the northwest-trending part of the Hines Creek strand. In the McCarthy quadrangle, this linear feature partially corresponds to the trace of the Totschunda fault system. Linear feature C, with a N. 45° W. trend, is over 700 km long and appears to extend from an area in the northernmost part of the Alaska Range to Seymour Canal in southeastern Alaska. Linear feature D, with a N. 45° W. trend, is also over 700 km long and corresponds partially to the Totschunda fault system in the Nabesna quadrangle (Albert, 1975). It can be traced from the northernmost part of the Alaska Range to near Tracy Arm in southeastern Alaska. Linear feature J, with a N. 51° E. trend, is over 250 km long and extends from the northern boundary of the McCarthy quadrangle to at least the town of Cordova. Projection of its trend, southwestward toward Hinchinbrook and Montague Islands, appears to aline with the Patton Bay fault (Plafker, 1969). Linear feature K, with a N. 46° E. trend, is ver 300 km long and seems to extend from Yukon Territory, Canada (about 75 km from the international boundary), to the southeastern side of Kayak Island and may correspond to the Ten Fathom fault (Plafker, Type A linear features observed on the Landsat imagery correlate in a limited, but possibly significant, way with aeromagnetic data (Case and MacKevett, 1976). Strong local aeromagnetic anomalies, which are presumably near the surface, seem virtually unrelated to these linear features. Broad aeromagnet: trends, on the other hand, which probably reflect much deeper magnetic regimes, show a fair correlation with type A linear features, suggesting that these linear features are deep seated. The type A linear features correlate well with Bouguer gravity anomalies (Barnes, 1976) (fig. 4).

quadrangle is located within 1 km of type A linear

One of the most significant gravity features is the strong gradient that extends from the northwest corner to the southeast corner of the quadrangle and is deflected eastward in the central part of the quadrangle. We believe that this gravity trend, with its eastward deflection, is described by northwesttrending linear features E, F, I, and by east-trending linear features G and H. Most of the known copper deposits in the McCarthy quadrangle are within this Since the gravity data are primarily regional in scope, they mostly reflect deep, regional features, such as changes in type and thickness of crust. We believe that the type A linear features correlate more closely with the gravity data than with the aeromagnetic data and thus infer that at least some are deep, Statistical correlations of known mineral deposits fundamental features that probably penetrate the with potential fault extensions or mapped faults are good (tables land 2). Although only 23 percent of the The correspondence of known mineral deposits to quadrangle is within 1 km of a potential fault extension type A linear features in the McCarthy quadrangle is or mapped fault, 72 percent (121) of all nonplacer very good (tables 1 and 2). There is a total of 167 mineral deposits in the quadrangle is within this known mineral deposits, excluding placers, which have area. Also, 74 percent (67) of all prospects and been subdivided into three groups: 1) mines, mines is within 1 km of a potential fault extension prospects, and 3) occurrences (MacKevett and Cobb, or fault. Thus, mineral deposits are 3.1 times more 1972; MacKevett, 1976b). Of the 167 known mineral common, and mines and prospects are 3.2 times more deposits, 91 (54 percent) are within 1 km of a type common, per unit area within 1 km of a potential A linear feature. Also, of these 167 deposits, 91 fault extension or fault, than in the overall are prospects or mines, 59 (65 percent) of which are within 1 km of a linear feature. Measurements using The area occupied by the six mineralogically a digital planimeter show that only 35 percent of the

features. Thus, mineral deposits are 1.6 times more common per unit area within 1 km of type A linear features than in the overall quadrangle (table 1). Additionally, prospects and mines are 1.9 times more common per unit area within 1 km of type A linear features than in the overall quadrangle. Even though type A linear features appear to be deep, crustal features and show a strong correlation with mineral deposits, their role in the formation of these deposits and local structural features, in the McCarthy quadrangle, is ambiguous. Detailed studies of conventional aerial photographs, geologic maps, and literature indicate that these linear features observed on Landsat images largely differ from the orientation of fracture patterns, joints or other structures at the known deposits. in the quadrangle (MacKevett, 1976a; oral commun., 1976) are: 1) the Nikolai Greenstone, 2) the Chitistone and

The most favorable host rocks for mineral deposits Nizina Limestones, 3) the Chitina Valley batholith, 4) a Tertiary granodiorite, 5) the Klein Creek pluton, and 6) possibly flysch deposits comprising the Valdez Group. Although mineral deposits within different rock types, and even within a specific rock type, may have different genetic affiliations, statistical correlations between known mineral deposits, the rock types listed previously, and type A linear features are very good (tables 1 and 2). Even though the area occupied by the six rock types within 1 km of a type A linear feature is only 4 percent of the quadrangle, 42 percent (70) of all nonplacer type known mineral deposits and 56 percent (51) of all prospects and mines are within this area. Also, 73 percent (51 out of 70) of all the known mineral deposits within this area is either prospects or mines. Consequently, mineral deposits are 10.5 times more common, and mines and prospects are 14.0 times more common, per unit area in areas where at least one of the six rock types occur within 1 km of a type A linear feature, than in the overall quadrangle (table 1). Type B Linear Features Linear features not related to the regmatic shear pattern, designated type B, afe probably the result of local and regional tectonics. Most of these tectonic linear features are 5 km long or less, numerous, and nearly ubiquitous. Longer linear features of this type are plotted as potential fault extensions. The short, type B linear features were analyzed as a group using a diffraction grating with a spacing of 8 lines per millimeter. As the grating is rotated through 180°, the trends of these linear features are enhanced when they are normal to the lines of the grating. The various trends are plotted on a compass cose (fig. 5) and their intensities subjectively rated modified by glacial activity. from weak to strong. In general, these trends correspond well to known structural data in the quadrangle (MacKevett, oral commun., 1976). The correlation between the trends of short type B linear features and the trends of type A linear features (fig. 3) is poor, however. The only trend that corresponds between the two is N. 47° W. These results seem to support Shul'ts' interpretation that planetary fractures are different from folds, joints, and faults caused by local and regional tectonic events. In addition, according to Lathram and Albert (1976), shorter linear features appear to be related to more recent tectonic events, whereas longer linear features (planetary or regmatic fractures) are older structures. The type B linear features that we plotted as potential extensions of faults mapped by MacKevett (1976a) (fig. 6) differ from the linear features (type A) that are related to the regmatic shear pattern. Whether or not the linear features actually are extensions of mapped faults is uncertain. These linear features have not been observed in the field (MacKevett, oral commun., 1975) and may be visible only on high-Numerous mineral deposits known in the quadrangle are closely related to faults and fractures (MacKevett, written commun., 1976), many of which have not been mapped by MacKevett (1976a). Since we believe that these type B linear features are possible faults, the correlation of known mineral deposits with these features has been extended to include faults mapped

favorable rock types that is within 1 km of a potential

area of the quadrangle yet contains approximately 60 percent (100) of the known mineral deposits. Within this area, 63 percent (17) of all known mines and prospects also occurs. Accordingly, mineral deposits are 15.0 times more common per unit area where the favorable rock units are within 1 km of a potential fault extension or fault, than in the quadrangle as a whole. Also, mines and prospects are 15.7 times more common per unit area where the favorable rock units are within 1 km of a potential fault extension or fault, than in the quadrangle as a whole. Analysis of the areas where linear features, potential fault extensions or faults, and any of the six favorable rock types coincide shows a marked correlation with known mineralization. Even though these areas occupy only 2 percent of the quadrangle, 35 percent (58) of all mineral deposits is located within them. Additionally, 44 percent (40) of all mines and prospects is within these areas. Mineral deposits, therefore, are 17.4 times more common per unit area where the linear features, potential fault extensions or mapped faults, and favorable rock units coincide, than in the overall quadrangle. More notably, mines and prospects in this area are 22.0 times more common per unit area, than in the overall quadrangle. Circular Features

QUADRANGLE LOCATION

Arizona, 1976

Background information relating to this map is published as

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Circular features observed on Landsat imagery that are more than 5 km in diameter were plotted in this study. The largest circular feature observed in the McCarthy quadrangle is approximately 120 km in diameter Circular features V, W, and X, in the southeastern part of the quadrangle, are primarily associated with e Paleozoic Kaskawulsh Group of Kindle (1953). ircular feature V, in particular, follows much of the thrust fault contact between the Kaskawulsh Group and younger rock units. Circular features Y and Z, in the western part of the quadrangle, are the only ones that appear to be related to mineral deposits. Virtually all of the deposits in the western part of the quadrangle are within these two circular features. Several large aeromagnetic anomalies that are fairly correlative with circular features Y and Z may be related to this mineralization (Case, 1976). Circular features we observed in the quadrangle do not correlate well with gravimetric and aeromagnetic data. Nevertheless, we believe that many of the circular features may be surficial expressions of magma chambers or intrusive bodies related to the Cenozoic volcanic and intrusive rocks within the

Wrangell Mountains. These features in turn have been

Iron-oxide Colored Areas Because of heavy snow cover, clouds, and low sun angle, color anomalies such as those recognized in the Nabesna quadrangle (Albert, 1975) could not be detected in the computer-enhanced Landsat sinusoidally stretched false color, simulated natural color, and color ratio imagery. However, we were able to use the simulated natural color image to identify apparent broad areas of iron-oxide coloration. Other areas of iron-oxide coloration have been observed in the field (Robinson and MacKevett, oral commun., 1976), but because of heavy snow and cloud cover in the imagery, we were unable to detect all of these areas. Many of the observed iron-oxide colored areas are not confined to one rock type -- individual areas can contain as many as six rock types (table 3). The most common associations are with Tertiary hypabyssal rocks, the Wrangell Lava, the Nikolai Greenstone, and the monzonitic-granitic complex. The correlation between observed iron-oxide colored areas and known mineral deposits is fair. Although these areas occupy only 5 percent of the total area of the quadrangle, approximately 28 percent (47) of all mineral deposits and 36 percent (33) of all prospects and mines are within them. Areas 28, 29, and 30 have the strongest correlations between mineral deposits and iron-oxide coloration (table 3). Correlations between the observed iron-oxide colored areas and aeromagnetic data is poor. Only areas 28, 29, and 30 appear to have any relation to aeromagnetic anomalies. These areas are close to significant magnetic highs that are attributed by Case and MacKevett (1976) to the Nikolai Greenstone and the Chitina Valley batholith. Only one notable correlation between observed iron-oxide colored areas and gravity data is evident in the quadrangle. Areas number 19 through 23 correspond to a significant gravity high in the central part of the quadrangle that may be related to a subsurface body of high-density material. Geologic features other than iron-oxide colored areas are visible on the computer-enhanced Landsat images. We believe that we are able to differentiate

alluvial grain sizes, define alluvial boundaries, locate

Percentage and Domains quadrangle area 1.0 1.0 1.0 I. within the McCarthy quadrangle 2.3 II. within 1 km of type A linear 3.5 III. within 1 km of type B linear features (potential fault extensions) or mapped faults IV. within the six favorable rock types V. where domains II and III are coincident VI. where domains II and IV are coincident VII. where domains III and IV are coincident VIII. where domains II, III, and IV are Table 1.—Relative incidence of the various types of mineral deposits within the domains discussed in the text

Relative incidence (frequency)

Deposits	Occurrences	Prospects	Mines	Mines and Prospects		Domains
167=a	76	76	15	91	A=total number	I. within the McCarthy quadrangle
100%	46%	46%	9%	54%	A/a=% of total number	
, 91=b	32	47	12	59	B=total number	II. within 1 km of type A linear
54%	19%	28%	7%	35%	B/a=% of 'a'	features
54%	42%	62%	80%	65%	B/A=% of each type of mineral deposit	
100%	35%	52%	13%	65%	B/b=% of 'b' for each type of mineral deposit	
121=c	54	55	12	67	C=total number	III. within 1 km of type B linear
72%	32%	33%	7%	40%	C/a=% of 'a'	features (potential fault
72%	71%	72%	80%	74%	C/A=% of each type of mineral deposit	extensions) or mapped faults
100%	45%	45%	10%	55%	C/c=% of 'c' for each type of mineral deposit	
126=d	49	62	15	77	D=total number	IV. within the six favorable rock
75%	29%	37%	9%	46%	D/a=% of 'a'	types
75%	64%	82%	100%	85%	D/A=% of each type of mineral deposit	
100%	39%	49%	12%	61%	D/d=% of 'd' for each type of mineral deposit	
72=e	29	34	9	43	E=total number	V. where domains II and III are
43%	17%	20%	5%	26%	E/a=% of 'a'	coincident
43%	38%	45%	60%	47%	E/A=% of each type of mineral deposit	
100%	40%	47%	13%	60%	E/e=% of 'e' for each type of mineral deposit	
70=f	19	39	12	51	F=total number	VI. where domains II and IV are
42%	11%	23%	7%	31%	F/a=% of 'a'	coincident
42%	25%	51%	80%	56%	F/A=% of each type of mineral deposit	
100%	27%	56%	17%	73%	F/f=% of 'f' for each type of mineral deposit	
100=g	43	46	11 ·	57	G=total number	VII. where domains III and IV are
60%	26%	28%	7%	34%	G/a=% of 'a'	coincident
60%	57%	61%	73%	63%	G/A=% of each type of mineral deposit	
100%	43%	46%	11%	57%	G/g=% of 'g' for each type of mineral deposit	
58=h	18	31	9	40	H=total number	VIII. where domains II, III and
35%	11%	19%	5%	24%	H/a=% of 'a'	IV are coincident
35%	24%	41%	69%	44%	H/A=% of each type of mineral deposit	
100%	31%	53%	16%	69%	H/h=% of 'h' for each type of mineral deposit	

Table 2.—Statistical analysis of the various types of mineral deposits within the domains discussed in the text

Chitina Valley batholith

Hypabyssal rocks Predominantly Upper Cretaceous

ower Cretaceous sedimentary rocks

hitistone and Nizina Limestones

Lower Cretaceous sedimentary rocks

Table 3.—Correlation of iron-oxide colored areas observed on Landsat

imagery with geologic and geophysical data

Chitina Valley batholith

EXPLANATION FOR GENERALIZED GEOLOGIC MAP SURFICIAL DEPOSITS

Pzk]- DEVONIAN(?)

SURFICIAL DEPOSITS Qu UNCONSOLIDATED SEDIMENTARY DEPOSITS (Quaternary) SOUTH OF BORDER RANGES FAULT METAMORPHIC ROCKS KJv VALDEZ GROUP (Cretaceous and Jurassic?) INTRUSIVE ROCKS Ti INTRUSIVE ROCKS (Eocene?) Typically, foliated granodiorite and tonalite

BETWEEN BORDER RANGES FAULT AND TOTSCHUNDA FAULT SYSTEM SEDIMENTARY, VOLCANIC, AND METAMORPHIC ROCKS QTw WRANGELL LAVA (Quaternary and Tertiary) Chiefly subaerial andesitic lava flows and tephra; includes local subaerial sedimentary rocks of the Frederika Formation K

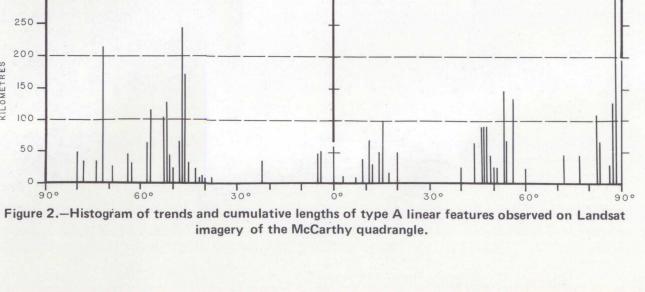
MARINE SEDIMENTARY ROCKS (Upper and Lower Cretaceous) Includes MacColl Ridge, Chititu, Moonshine Creek,
Schulze, and Kennicott Formations, and unnamed Lower Cretaceous rocks MARINE SEDIMENTARY ROCKS (Jurassic and Triassic) Includes Root Glacier, Nizina Mountain, Lubbe Creek, and McCarthy Formations, Kotsina Conglomerate, and Nizina and Chitistone Limestones া NIKOLAI GREENSTONE (Upper and (or) Middle Triassic) Mainly subaerial tholeiitic basalt; includes subordinate
Chitistone Limestone north of Totschunda fault system PTPs SKOLAI GROUP (Permian and Pennsylvanian) As mapped includes a few scattered remnants of Middle Triassic sedimentary rocks in northeastern part of quadrangle P IPsm METAMORPHOSED SKOLAI GROUP (Permian and Pennsylvanian) Incl<mark>udes</mark> a few small outcrops of serpentinized ultra-mafic rocks near Border Ranges fault

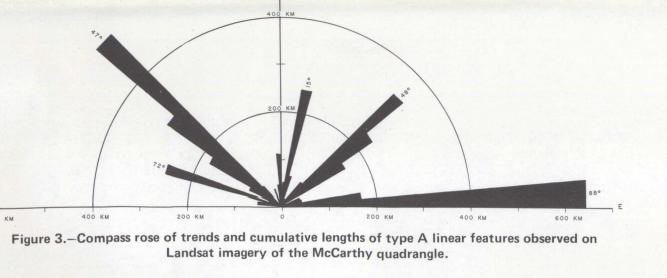
Pzk KASKAWULSH GROUP OF KINDLE (1953) (Devonian?) INTRUSIVE ROCKS Th FELSIC HYPABYSSAL ROCKS (Pliocene) Mainly porphyritic dacite GRANODIORITE (Pliocene) Unfoliated granodiorite with local mafic border facies CHITINA VALLEY BATHOLITH (Jurassic) Mainly foliated quartz monzodiorite, granodiorite, and tonalite GABBRO Pm MONZONITIC-GRANITIC COMPLEX (Pennsylvanian) Mainly nonfoliated quartz monzonite and granite, local mafic border facies Pgo GABBRO AND ORTHOGNEISS (Pennsylvanian)

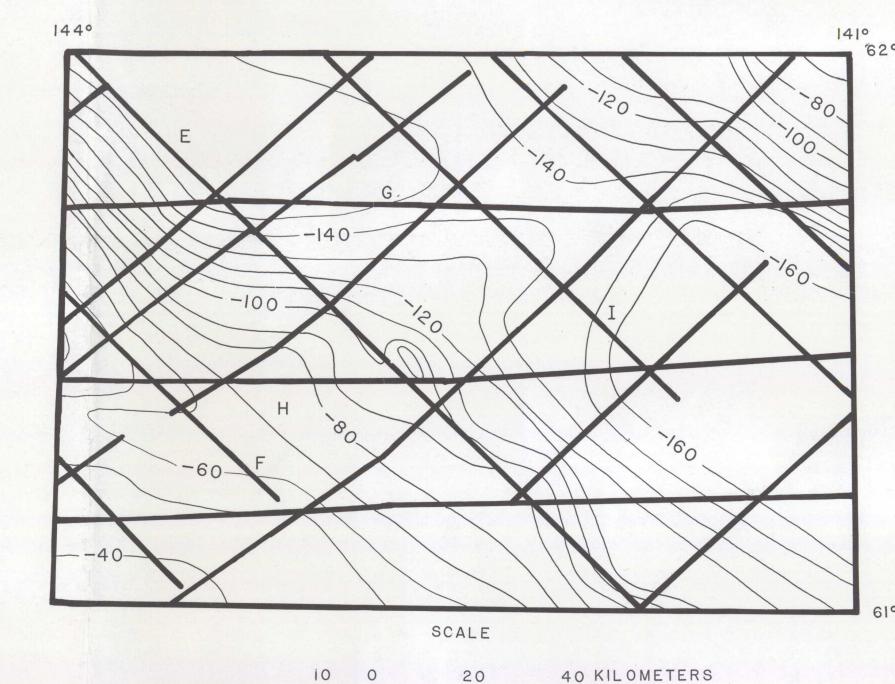
NORTH OF TOTSCHUNDA FAULT SYSTEM SEDIMENTARY AND VOLCANIC ROCKS QTw WRANGELL LAVA See above CHISANA FORMATION (Lower Cretaceous) Marine and subaerial volcaniclastic and volcanic rocks KJs NUTZOTIN MOUNTAINS SEQUENCE (Lower Cretaceous and Upper Jurassic) NIKOLAI GREENSTONE See above PTPs SKOLAI GROUP See above INTRUSIVE ROCKS

Th FELSIC HYPABYSSAL ROCKS See above Kkg KLEIN CREEK PLUTON (Cretaceous) Chiefly granodiorite ____... Contact; dotted where concealed High-angle fault; dotted where concealed Thrust fault; sawteeth on upper plate. Dotted where concealed NOTE: Areas without letter symbols are glaciers and snowfields

Figure 1.-Index map of Alaska showing the approximate location of the McCarthy quadrangle, and linear, geologic, and geographic features outside the quadrangle that are described in the text.



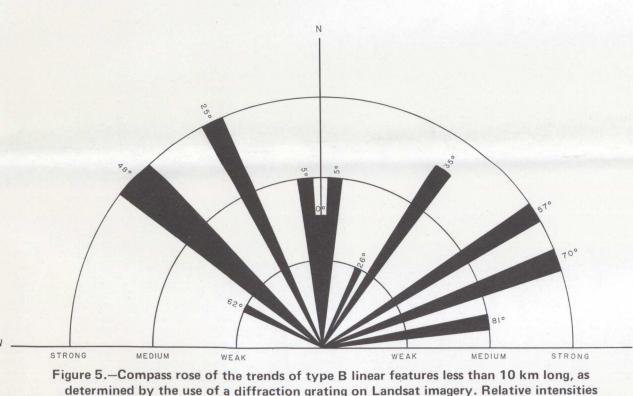




EXPLANATION BOUGUER GRAVITY CONTOUR, IN MILLIGALS. INTERVAL 10 MILLIGALS. MAJOR LINEAR FEATURE THAT CORRELATES WITH GRAVITY ANOMALY ETTERED FEATURES ARE DESCRIBED IN TEXT

Figure 4.—Bouguer gravity anomaly map of the McCarthy quadrangle (Barnes, 1976) with major type A linear features

observed on Landsat imagery.



determined by the use of a diffraction grating on Landsat imagery. Relative intensities

differentiate morainal materials, and, in a few places, identify bedding. The determination of the economic significance of any of these phenomena requires additional investigation.

CONCLUSIONS

There is a good correlation between known mineral deposits and type A linear features and between known mineral deposits and potential fault extensions (type B linear features) or faults in the McCarthy quadrangle, Alaska. The correlation is significantly better where these features occur in rock types with the greatest potential for economic mineral deposits: the Nikolai Greenstone; the Chitistone and Nizina Limestones; the Chitina Valley batholith; Tertiary granodiorite; the Klein Creek pluton; and possibly the Valdez Group. The areas of the highest frequency of mineral deposits per unit area are where at least one of the six favorable k types, type A linear features, and potential fault extensions (type B linear features) or faults coincide. Additionally, these correlations are better for mines and prospects than for mineral deposits in general. Although the iron-oxide colored areas identified on computer-enhanced Landsat imagery (simulated natural color) do not necessarily represent specific exploitable areas, they probably are worthy of further exploration. In fact, several areas dentified from independent data by Singer and MacKevett (1976) as having exploration potential correspond to areas of iron-oxide coloration observed on Landsat magery. Thus, whereas undiscovered mineral deposits in the McCarthy quadrangle cannot be identified solely by Landsat imagery, using it in combination with geologic, geochemical, and geophysical data helps to delineate areas with favorable potential for mineral

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EXPLANATION MAPPED FAULT MAPPED THRUST FAULT ---- WELL-DEFINED POTENTIAL FAULT EXTENSION - POORLY DEFINED POTENTIAL FAULT EXTENSION Geol. Survey open-file rept. 76-70, 1 sheet, scale Misc. Field Studies Map MF-773B, 2 sheets, scale mineral resources map of the McCarthy quadrangle, Alaska: U.S. Geol. Survey Misc. Field Studies Map ☆Interior—Geological Survey, Menlo Park, California—1976 5 0 5 10 15 20 25 KILOMETERS Figure 6.—Map of type B linear features (potential fault extensions) observed on Landsat imagery of the McCarthy quadrangle with mapped faults (MacKevett, 1976a).

fault extension or fault is only 4 percent of the total areas of possible near-surface bedrock in the alluvium, INTERPRETATION OF LANDSAT IMAGERY OF THE McCARTHY QUADRANGLE, ALASKA

Nairn R. D. Albert and Wm. Clinton Steele